ON THE PRESERVATION OF LIFE AND PROPERTY FROM FIRE.

J. H. HEATHMAN.

With the Author's Compliments

ON THE

PRESERVATION OF LIFE

AND

PROPERTY FROM FIRE.

BY

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INTRODUCTION.

On very many occasions it has occurred to me that a work has been greatly needed, to the pages of which the property owner and other interested persons might make reference to readily ascertain the points to which their especial attention should be given, and the measures of precautions which should be exercised in order to reduce the chances of a fire occurring, and prevent the possibility of such a misfortune arising from simple mis-arrangements, and in this direction it is intended that this book shall furnish as much information on the subject as my ability will at present afford.

During the past six years my capacity has called me to all parts of Great Britain to survey buildings of almost every description, in order that I might design and report the measures I considered essential for adoption with a view to the preservation of the respective buildings and their contents against fire; and I have at all times been careful to avail myself of any information which appeared to me might prove useful

in the prosecution of my profession—that of a Fire Engineer.

I have taken pains to ascertain the weak as well as the strong points of buildings; the quality of the materials composing their structure, the manner in which they are used, their soundness, solidity, and suitability for the purpose of protecting against, retarding and arresting, the progress of destruction by fire, as well as the construction and safe fixing of the machinery and appliances for the requirements of the business, and lighting, heating and ventilating of the premises.

I have planned and supervised the provision of apparatus and arrangements for the procuration, storage and distribution of water for fire extinguishing, domestic and other purposes; have had intercourse with, and advised, architects, builders, engineers and property owners of almost every class, fire brigades, Government, insurance, and other officials; assisted the formation of fire brigades in towns and villages, as well as private or "Amateur" brigades on estates and in business and other establishments, for the guidance of whom I have prepared reports, rules, etc., and given personal instruction as to the proper steps to be taken in the event of, and to suppress an outbreak of, fire.

In June, 1879, I was elected on the Council of the National Fire Brigades' Association.

In 1876 I became a member of the London Auxiliary Fire Brigade, and as a recognized voluntary auxiliary

to the Metropolitan Fire Brigade, I have, by the kindness of its officers, been enabled to assist in the extinguishment of fires, and gain experience of the effects heat, smoke, and water will produce upon matters.

I have been careful to ascertain how fires originated, and to observe the manner in which they developed, and form an idea how they might in very numerous instances have been easily prevented; and might add, that I periodically visit several establishments of repute for the purpose of giving advice on questions generally appertaining to the prevention of fire.

In publishing this work, my experience leads me to believe that I am conveying information which possesses intrinsic value for the benefit of persons owning or having interest in the management of warehouses, factories, stores, docks, wharves, banks, mansions, hotels, clubs, colleges, hospitals, asylums, workhouses, barracks, gaols, and other buildings, including even the ordinary private dwelling, and as, in almost every instance, a person's property depends for its happy immunity from fire upon the care and attention of the servants and others about him, and as the majority of fires owe their origin to some action or omission, accidental or otherwise, on the part of an employé, incalculable benefits will undoubtedly accrue from employers' distributing copies of this work among those persons to

whom they have to look for the preservation of their property and interests.

In conclusion, I confidently expect that whatever merits this work may possess, will be appreciated by its readers, and I hope it may prove for the public good.

JAMES HENRY HEATHMAN.

63, Long Acre, London, W.C.
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A MORE overwhelming disaster cannot befal a law-abiding individual than to have his property consumed by fire, and yet how frequently have I been shown over some building which is furnished in a comfortable, convenient and elegant manner, the like of which no amount of insurance could replace if the omnipresent element of fire once gets at work and finds its way from basement to attic, in spite of the shrieks of the family and neighbours, and the yells of the populace, or the earnest hard work of the firemen, when they arrive too late to be of any service; it is an astonishing fact that in the majority of cases the possibility of such a catastrophe receives no consideration until the hour of danger has actually arrived to make it manifest.

In *every* establishment there exists a possibility that a fire may occur from one cause or another, and it is necessary, therefore, that constant and vigilant precautions should at all times, and in all places, be practised to prevent, or reduce the risk of, an outbreak which might result in a lamentable loss of both life and property.

Fully three-fourths of all fires that have occurred might have been prevented by the exercise of prudence, care, or foresight on the part of some occupant, builder, or other person, and it will be apparent that if attention is paid at the proper time to one or other of the practicable precautions which it is my intention to enumerate, many "would-be" conflagrations will be prevented, which would otherwise have a disastrous result and probably imperil an entire neighbourhood.

Furnaces, fire-stoves, candles, lamps, gas, matches, tobacco pipes, cigars, and other ordinary things are perfectly harmless when properly controlled, but it is, nevertheless, very necessary to put a strong curb upon their use, in order to prevent the possibility of their overstepping the boundary of safety.

Very frequently I hear statements such as, "We have no stoves or gaslights to cause a fire," "We have nothing to burn," "We have never had a fire," "We are insured," "Our building is fire-proof," and such like, but having invariably found that they have been made without a proper consideration of the subject in question, I have learned to treat such remarks according to their worth, and advise *every* person to carefully and frequently consider that a fire *might* occur, notwithstanding the greatest precautions that may be taken to guard against such a calamity.

Accidents will happen, and fires will occur, but as it

is said that "To be forewarned is to be forearmed," I am of opinion that a person who has fully and frequently pre-considered the subject will be better prepared to act with composure and success in the hour of danger, than one who has been thoughtlessly resting on the assurance that perfect immunity from fire would ever prevail in his particular case.

"Prevention is better than cure," and studious attention on the part of the readers of these pages may lead to an improved security of both life and property from destruction by fire, and which result will not fail to prove this work a benefit to the community.

SECTION I.

PRECAUTIONS TO WHICH ATTENTION SHOULD BE GIVEN GENERALLY, IN ORDER TO REDUCE THE RISK OF FIRE.

Matches, tapers, candles and lamps, when ignited, should be carefully carried and made use of; great caution being exercised to prevent the possibility of their flames coming in contact with inflammable material, and as soon as the light is no longer required it should be extinguished.

Matches should not be dropped, or left about in a careless manner, where children may have access to them, or where there is a possibility of their being trodden upon, nibbled by rats, mice, birds, etc., or heat arising at any time sufficient to kindle them.

Consumers would do well to purchase only those matches which are known to be of a reliable character, as some of the foreign as well as the home-made kinds which are sold at a very low price have been found to vary materially in their safe qualities.

It is to be regretted that the public have been led to place far too much confidence in lucifer matches, which, although frequently contained in boxes labelled "Protection from Fire," "Safety," etc., are in reality

of a most dangerous nature, and it is therefore desirable that every reader should be impressed with the importance of watching the tiny stick, tipped with inflammable composition, when in the act of "striking a light," because it so frequently happens that whilst this operation is being performed a portion of the composition will fly off; several extensive conflagrations have resulted from such sparks alighting upon combustible material, and in some instances these disasters have been accompanied with a lamentable loss of human life.

A whole box of matches will sometimes take fire by a single spark from a lucifer falling into it when one is being struck upon the box, and there is also a possibility that the contents of a box which is too well filled, may become fired by friction during the act of closing, and to prevent the danger which must ensue in such a case, every person should carefully look at the box after making use of it, before laying it aside. The common practice of placing a match upon the box after using it, and before it has quite died out, is also dangerous, and too much weight cannot possibly be attached to the very great importance of effectually extinguishing a match, fusee, taper or other artificial light before casting it away, whether inside a building or in the public thoroughfare, because more than ten per cent. of the fires which occur emanate from such lights being dropped, or thrown down whilst still in combustion.

Paper should never be used for the purpose of obtaining temporary and portable light on account of the uncertainty of its inflammable nature.

Candles should not be allowed to burn down so completely as to set fire to anything on or near which they may be standing, and when they do not of themselves properly fit the socket of a stand, a metallic false socket should be used. It is best to use an "extinguisher" to put out the light, because sparks are apt to fly from the wick when the "blowing out" process is resorted to.

Lamps for oil or spirit should always be used with caution. As inferior burning liquids will frequently evaporate and flash into flame at a low degree of heat, it is important that none but the best qualities of oil or spirit should be used. They should always be filled by daylight and re-filled previous to each using, and when lighted and left burning for some time, the wick should never be turned down and the lamp put aside, because a certain supply of gas is created from the oil when burning, which continues to flow when the wick is turned down, and if not properly consumed forms an inflammable gas in the chimney, which will explode when a sufficient quantity of air has mixed with it in the presence of light. An explosion may also happen if a person blows down the chimney, and it is therefore advisable that a lamp should never be put out in such a way.

Only such lamps as are of good and strong manufacture should be used, as the common kinds possess dangerous qualities, and for domestic purposes purchasers should at all times be careful to select only those lamps which are fitted with the Patent Extinguisher, by means of which the slight depression of a lever instantly extinguishes the flame, thereby avoiding the inconvenience of turning down the cotton, and removing the possibility of winding it into the oil, which, if not of the best quality, might ignite. The cottons are also protected from dust and dirt when out of use, and all evaporation is entirely prevented. The unpleasant odour inseparable from the ordinary method of extinguishing hydrocarbon oil lamps is also entirely removed by the adoption of the Patent Extinguisher, which is now made by the majority of the lamp manufacturers.

In the lamp which is known as the "Empress," an air space is formed between the oil reservoir and the exterior casing, through which an upward current of cold air is blown by a small fan rotated by the gradual expansion of a spring, and this circulation of air tends to prevent the oil reservoir from becoming heated, and thereby reduces the risk of danger.

When the reservoir of a lamp is being charged, no light should be near it; and any of the liquid that may be spilled on the outside of the lamp should be carefully wiped off before a light is applied to the wick.

Any cloth or garment which is saturated with oil or spirit should on no account be placed near a light, nor yet laid aside; but at once washed and hung in the air unfolded, until the spirit has dried or evaporated therefrom.

Wadded lamps intended for burning benzolene or petroleum should have the superfluous oil poured out after being filled, because it is only necessary to have sufficient oil therein to well saturate the sponge or wadding, and more than this quantity may prove dangerous.

Lamps should at all times be firmly placed where there can be no possibility of their falling or getting turned over.

Leaky or faulty lamps should on no account be used; and bottles, jars, or cans containing lamp oil or spirit should be properly labelled, and kept well-stoppered, in a cool place.

In the event of lamp spirit, oil, or other gaseous products taking fire, it may be extinguished by a wet cloth or mat, earth, sand or milk, being thrown upon it, and if no means other than water is at hand, attention should be directed to apply it to prevent the flames extending to the surrounding material, as little or no good can be done by dashing water upon burning oil or spirit, because it may float, and possibly cover a larger area with fire than before. Under certain conditions water might suffice, but extreme caution is necessary.

Every *gas flame* should be effectually protected with an incombustible globe or guard, and when a reflector or shade is required, it should be *metallic,* as the risk of fire is greatly increased by the use of paper or card reflectors, which are now so generally adopted.

Great caution should always be exercised to prevent the possibility of curtains and other inflammable articles getting in contact with a gas flame when blown by a current of air or otherwise, and wooden shelving should be fixed only in positions of safety.

Jointed *gas brackets* are very frequently fixed in such a position as to render them extremely liable to cause a conflagration, and where they exist vigilance should always be exercised to prevent the possibility of the burner-end being turned at any time, causing the flame to come into contact with wood, paper, curtains, or other inflammable material. In some instances it would be wise to replace them with brackets having no turnable joints; in others, the existing joints could be made so that they will not turn, while where this would cause inconvenience, the radius through which they could be turned should be limited by fixing stops, against which they would strike, before reaching any point of possible danger.

When shields are fixed to prevent heat operating upon combustible material above a gas or other flame,

they should be of metal securely hung so as to swing, and by keeping up a light motion serve to distribute the ascending products of combustion ; and gas burners should not be fixed so close to match-boarding that the flame would, if blown by a current of air, scorch and possibly ignite the woodwork.

The work of fixing sun-burners and other concentrated lights should be entrusted to persons of experience, as numerous destructive fires have been caused through imperfect fixing of such articles, and unless a properly contrived *self-acting* valve is fixed within the ventilating pipes or shafts which are invariably provided to carry off the fumes generated by concentrated gas lights, there is a serious risk of explosion if the gas be turned on and a light afterwards applied, through neglect or ignorance to first open the valve. The object of the valve referred to is to prevent a down-draught of cold air when the gas is not lighted.

All ventilating or flue-pipes in connection with sun-burners should be kept at such a distance from woodwork or other inflammable material as to ensure safety, and they should be periodically examined by practical men in order to ascertain if they are in a sound condition.

Each *gas burner* should be carefully and fully turned off when the light is no longer required, and in every case where the meter-tap is turned off at night, the duty of so doing should be assigned to a responsible person,

who should also turn it on again when required, and be impressibly instructed to make a careful examination of each burner-tap immediately after turning on at the meter, in order to ascertain that each burner is fully turned off, and until this inspection has been made it would be well not to take a light into any room without first being satisfied that no escape of gas has occurred. No doubt such a course of inspection would, in the case of large establishments, be difficult, if not almost impossible, to carry out, but it is well to mention it, because several instances have occurred where, after the supply has been shut off at the meter, a burner-tap has been turned on, and so left; with the result that after the supply has again been turned on, the gas has escaped probably for hours, until some person has chanced to discover it, or an explosion has occurred. The latter source of possible danger might be prevented by affixing a pipe of half inch or smaller bore from the meter side of the main tap to the distributing side, so arranged that when the main supply was shut off the gas would continue to pass through the small "pass pipe" referred to and so keep the whole of the distributing pipes full of gas and enable a few of the gas burners to be used, but not the bulk.

Some discretion should always be displayed when selecting a point at which to fix a gas meter; wherever possible, the meter should be placed in an area outside the main wall of the building, and in such a position that

any gas which might escape from the meter or its connections will not accumulate or enter the building, but pass direct into the open air.

In every case where gas is used in a building, a stop tap should be fixed in the main supply pipe immediately before it enters the premises, with a surface box and cover fitted in the ground, so that a key could be applied to turn off the whole supply in the event of an explosion or a fire, without it being necessary to enter the building for such a purpose. Gas companies should insist upon this provision, and initiate a standard size for the spindle of the stop taps, so that a key of one pattern would suit the whole of the taps in their district.

Lead and composition-metal pipes are objectionable for conveying gas in a building of any description, because they will quickly melt under the action of a fire and allow the gas to escape and add to the danger both of fire and explosion. They are also easily gnawed by rats and mice, and the custom of fixing such pipes behind match-boarding, between ceilings and floors, and embedded in walls where they are not discernable, is to be strongly condemned, as in such positions it is difficult to detect any fault, and there is a possibility that at some time or other a nail may accidentally be driven into them and an escape of gas result.

All *gas pipes* should be composed of iron or other

equally hard metal, and where they are of brass or copper the tube should be solid drawn; brazed tubes should not be used, because the brazed joint becomes impaired in course of time, and a rupture may take place through which the gas will escape.

When *an escape of gas* occurs, extreme caution is necessary in taking steps to discover the cause, or serious consequences may result. No light should be taken into a room where there is a smell of gas until some competent person has satisfied himself that the percentage of gas mixed with the air in the room is such that the mixture is not explosive; all doors and windows should at once be opened wide, and if the escape is at all serious and the defect cannot be readily ascertained and remedied, a gas-fitter should be sent for; but, as even these persons have been known to so far forget themselves as to make use of a light to seek an escape and cause fatal results, it will be well to caution the gas-fitter against recklessness upon his entering the premises.

No light should be used to test a line of pipe in walls or flooring, because an explosive mixture of gas and air may have accumulated in some unexposed place which may readily explode on meeting with the light; under some circumstances a defect may be found by a person passing his hand closely and slowly over the gas pipes and occasionally placing that hand to his nostril in order to ascertain if it has come in contact with gas, in which case its odour will be perceived by

the nose, and the locality of the defect thus made known.

The *electric light*, which is now being rapidly adopted in buildings, has already proved itself not altogether proof against causing outbreaks of fire, and it is, therefore, important that public attention should be directed thereto. In every case great care should be taken to see that every part of a wire used for conducting powerful currents of electricity is of an ample thickness to convey the electrical power which will be forced through it, and each wire should be thoroughly insulated and fixed in its entire course through a building at a safe distance from woodwork or other inflammable material, secured with non-conducting fastenings, so that it will not get in contact with any other electric wire.

All electric lights should be enclosed in glass globes without any opening at the bottom, so that sparks or particles of the carbons if thrown off will not fall upon and ignite inflammable material. When a globe has an opening at the top there should be a spark-arresting chimney fitted to cover it. The conducting framework of chandeliers and lamps should be insulated the same as the wires, and naked electric lights should never be used. When a building is illuminated by electricity which is conveyed into the premises from an external source, there should be a "shut-off" at the point where the wires enter the building, so that the main current

may be readily stopped when the lights are no longer required as well as in case of fire, and such a "shut off" should be accessible outside the building.

Fire stoves when in use should be fitted with a wire guard, which will prevent sparks flying out beyond the fender, and a person's or children's clothes getting too near the material in combustion. When clothing, etc., is placed before a fire to air or dry, care should be taken to prevent its overheating, falling inside the fender, or a spark getting near it; and children should not be left without supervision in a room where there is a fire or other artificial light accessible to them.

It is a good practice to so regulate a fire that it will burn out by the arrival of the hour for retiring to rest, and what burning embers remain at this period should not be raked out on to the hearth, but left in the grate. When a fire is required during the hours of slumber, it should be made up carefully, and a wire spark-guard fixed to the grate before retiring to bed.

Kitchen and circulating boilers have so frequently exploded and caused fatal and disastrous results, on account of an accumulation of pressure in the boiler in consequence of the outlets being stopped up while the fire is burning, that it is of great importance that every boiler of the kind, whether constructed of cast or wrought iron, or of copper, should be directly fitted with a reliable safety valve, which, in the event of the outlets becoming choked either through the formation

of ice, the accumulation of sediment, or the accidental shutting of a stop tap in any part of the pipes, would relieve any undue pressure and at the same time create a noise which would apprise any person near that something was wrong.

The cold water cistern and its ball tap should be occasionally examined to see that the water-supply is free, and in the time of frost especial care should be taken to see that the safety valve mentioned above is in good working order, and if one is not already fitted the sooner it is done the better, as without such a provision the boiler will in all probability burst and lay both life and property in wreck and ruin should the circulation at any time get stopped and the pressure of the heated water bottled up.

Enclosed *stoves,* whether intended for gas or fire, *furnaces* and their *flues,* as well as *hot-air, water* and *steam pipes,* should be fixed only by experienced persons, who should be instructed to adopt every precaution to prevent a possibility of an outbreak of fire being caused at any time should they become overheated; and for this end great care should be taken that they may not come in contact with woodwork or other inflammable material. Wood subjected to a constant heat becomes in time chemically changed in its nature; desiccation is continually going on, extracting the oxygen contained in the wood in its natural state, leaving it composed of nearly pure carbon, when

the slightest increase in heat over that to which it is ordinarily subjected will produce combustion; and in the event of a fire occurring from any other cause in a building in which due care has not been taken to prevent the contact of woodwork with steam-pipes and heating apparatus, the fire has every chance to quickly develope itself by rapidly seizing upon the carbonized wood, and cause flames to break out in various parts of the building at almost one and the same time, thereby rendering the efforts of the firemen unavailable to its early extinguishment.

No pipe for conveying heated air or steam should be fixed nearer than six inches to any combustible material, nor one for hot water nearer than three inches, nor any for conveying smoke or other products of combustion nearer than nine inches.

It is a dangerous practice to place portable gas and fire stoves upon plate iron or other metal laid direct on to wood flooring or benches, because when the metal plate gets heated the wood underneath it becomes gradually charred, and liable to smoulder and finally burst into flame, whereas if the metal plate were fixed some three inches above the timber, and the space either left for the circulation of a current of air or filled in with some non-conducting material, the charring would not take place. This may also be said to apply to the similar protection of woodwork and other combustible material over or near gas flames.

The floor under every stove or oven, and for a space of eighteen inches around, should be formed of materials of an incombustible and non-conducting nature.

Ashes should be *perfectly cool* before being put into scuttles or boxes, or thrown into a dust chamber, or on ash pits. Receptacles for dust and refuse should be constructed without combustible material in or communicating with their interior, because there is frequently a liability to spontaneous combustion in consequence of the multiplicity of substances that are deposited therein; it is also advisable that they be frequently cleared out.

It is a singular fact that "defective chimneys" occupy almost the foremost place as the cause of fires, and by far the majority of fires in private residences owe their origin to ill-constructed or foul flues.

Many *chimneys* are built only four and a half inches thick, and with a small supply of mortar, so that a very little settlement in the foundation will suffice to make a large cavity in the interior, and these slight walls are frequently plugged with wood, and match-boarded on the exterior, so that when the brickwork gets heated, the timber participates and in course of time ignites. The adoption of a fire-place lintel in the construction of chimneys will secure a better construction of flue, and dispense with the large spaces over fire places where soot accumulates, thereby affording an improved protection from fire; and it is

essential that all chimneys and flues should be effectually swept and cleaned at regular intervals, as the action of coal-gases, absorbed by the soot, is liable to honeycomb their interiors.

If the soot in a chimney should take fire, it may be extinguished by plentifully sprinkling powdered brimstone or salt upon the fire in the grate, so that it will burn and emit fumes into the chimney, and while such fumes are ascending, the opening at the top of the chimney should be covered with a wet carpet, rug, mat, blanket, or board, and the opening in the room might be covered also, to confine the deadening fumes.

If the chimney is very foul and "well alight," or if the ends of joists, beams, or any woodwork be in the chimney, water should be poured in at the top from a water-pot having a rose on the spout, or a hand-pump may be used with advantage to eject water either up or down the chimney, according to the construction of the latter.

Combustible material should never be put into chimney openings or flue pipes, and when such places are not intended to be used again, they should be securely bricked up or protected by metallic coverings, both at the top and bottom.

Smoking in bed is dangerous, and those who smoke should at all times be careful to prevent sparks falling from the "weed" on to wearing apparel, carpets, etc.,

as well as not to lay a pipe or cigar upon inflammable material, unless it is quite extinguished.

The habit among working men of placing a pipe in their pocket while the tobacco is still smouldering is very dangerous. When a fuzee, lucifer, taper or piece of paper is used to light cigars or tobacco, care should be taken at all times, and in all places, to fully extinguish the flame before casting it away, and this precaution should likewise be taken with cigar ends and refuse tobacco.

Reading in bed by the light of candles or lamps should never be indulged in, or it may lead to fatal results.

Where *wood-working, packing* or *unpacking of goods* is carried on, accumulations of inflammable material spread over the floors should not be allowed to remain longer than necessary, and every room used for such a purpose should be cleared up and arranged each evening before the men leave their work.

The basements and other parts of business premises should not be kept in the condition in which they are so frequently found—littered with a miscellany of paper, straw and packing boxes and materials; and wherever there is an area or iron grating opening into the street, care should be taken at all times to prevent combustible material from lying about in places where it might be ignited in the event of a person, when passing along the street, dropping a

lighted cigar or lucifer through the grating or otherwise into the area, cellar or basement; because such an occurrence has often led to an outburst of fire which has ended in a large and expensive conflagration.

The windows of all buildings should be closed during the night.

When premises are under construction, repair or alteration it should be determined between the proprietors and contractor that every care shall be exercised by the workmen to prevent a fire occurring from the men smoking, making temporary fires, or other action on their part, and this should especially be borne in mind when entrusting work to plumbers, because many buildings have been burned down from the carelessness and oversight of men of this trade.

Fires frequently occur which appear to have had a mysterious origin, and there is no doubt that many of them may be attributed to the existence of what is called latent heat, which slumbers confined in all organic matters, and which, under certain conditions, instantly becomes active in the shape of spontaneous ignition as a product of chemical oxidation.

Sulphuric acid mixed with cold water in certain proportions, or water poured upon unslaked lime, will develope intense heat, and if nitric acid, iron and water are combined the mixture will become boiling hot within a few seconds; while certain substances without contact with any chemical agents, such as

hay, cotton, and woody fibre, including tow, flax, hemp, jute, rags, leaves, spent tan, cocoa-nut fibre, straw in manure heaps, etc., when stacked in large quantities in a damp state, undergo a process of heating from simple oxidation or fermentation, and after a time some of them may pass into a state of *spontaneous combustion.* Newly stacked hay, insufficiently dried, becomes, after a few days, hot in the centre of the stack, and aqueous vapour or steam escapes; this is followed by smoke of a peculiar odour of partially burnt vegetable matter, and on examining the interior of the stack at this time, the hay will be found of a dark brown colour, almost charred. At a still later period a thick smoke will issue, followed by ignition on exposure to the air.

Azotised substances, or those organic matters, whether animal or vegetable, which contain nitrogen, damp corn, etc., are liable to fermentation, but it is not usual to hear of the heat reaching the kindling point.

Raw cotton, stacked in quantities or packed in the hold of a ship before it is thoroughly dry, undergoes a series of changes similar to hay, and is liable to ignite by the access of air.

Cotton and woollen materials, hemp, tow, flax, paper, sawdust, etc., imbued with oil or spirit of any kind, and collected in a heap under circumstances favourable for the retention of heat, are very liable to ignite spontaneously.

In respect to the prevention of fires from this cause the greatest neglect is shown by servants, who store cupboards and "out of sight" corners and places with articles of every kind and description without the slightest thought of the possibility of a fire being induced from spontaneous ignition; no doubt ignorance on this important subject is the main cause of negligence. In demonstration of this statement the author, when making an inspection of a large mansion, actually found a leaking can of paraffin oil placed among some cleaning cloths and other varieties in a cupboard through which a hot water pipe passed; fortunately a servant had but that day placed the can there, so sufficient time had not elapsed to demonstrate the possibility of an outbreak of fire, the origin of which would doubtless have been a "mystery."

Oily waste and wipings should not be permitted to lie in heaps unless deposited in metal boxes or brick pits where spontaneous combustion would not prove dangerous. In large mills and other places where a quantity of such material is in use, it is a good plan to have the metal boxes mounted upon wheels, so that they can be run away to a place of safety at any time.

Friction of machinery through being imperfectly fitted or neglected, or from insufficient lubrication, is also the cause of many conflagrations, and in this

direction some attention should be paid to prevent the possibility of neglect or carelessness on the part of those workmen engaged in mills and factories on whom the duty of attending to machinery devolves.

Good lard oil is recommended for lubricating machinery, as it is a question whether the low priced lubricants from petroleum which are now so strongly pushed among mill owners has not been the cause of many fires.

Several qualities of *coal* if stacked while damp are liable to spontaneous combustion, and when large quantities of coal are heaped together in cellars and other confined places care should always be taken to provide sufficient ventilation to prevent a dangerous accumulation of gas which may be generated by the self-heating of the coal.

The rays of the *sun* when focussed through glass may concentrate sufficient heat to ignite lucifer matches or other highly inflammable material, and the possibility of outbreaks of fire through *lightning* should not be passed without mention. Every large building should be fitted with an efficient lightning conductor.

It is a question whether the general practice of large property holders to insure all they possess does not tend to lessen the constant vigilance which is the most essential requisite for preventing fires. Thousands of proprietors never keep a sovereign's worth of goods in

store that is not covered by *insurance,* and they make this cost a regular charge upon their business as peremptorily as they do the salaries paid to their employés; and while it does not follow but that many merchants and manufacturers exercise due watchfulness over the property so insured, it is a fact that in the majority of instances the thoughtfulness is much less complete than it should be—the care wonderfully lacking in personal supervision with what would be the case were each one his own insurer. This of course in no way casts the slightest opprobrium upon the advisability of insurance, but in fact shows the greater necessity why risks should be so provided against that they may not suffer from the carelessness of a neighbour; it also points to the necessity of continually increasing care and thoroughness of inspection on the part of insurance companies as well as the insured.

A particular inspection of every building, whether a small residence or a large warehouse, should be made each night at the last moment before the occupants seek tranquility and repose for the night, in order that it may be made certain that no fire is smouldering or in existence—that all gas lights or fires have been put out, and that there is nothing apparent which may cause a conflagration—and this duty should be undertaken by the head of the family in the case of a private residence, and by some fit and responsible

person in the case of a warehouse or other business establishment; the person making such a tour of inspection should visit every room, and throughout exercise his organs of sense, taking care to shut each door after him.

In all extensive premises containing valuable property, one or more watchmen, who are suitable and trustworthy persons, should be employed to inspect each room in the building, at regular and frequent intervals during the night, and record such visits upon tell-tale clocks, fixed within each room, so as to make certain that he is at all times vigilant. Such watchmen should have free access to all the fire extinguishing material with which the premises are provided, and be fully initiated in their manipulation as well as the steps that should be taken in the event of their discovering or being apprised of a fire.

When watchmen are allowed to use a lamp for making their inspections it should be a good one for burning colza oil, and it should on no account be permitted to be used when not in a sound condition. Whenever a person has reason to believe that there is a possibility of a fire occurring within any premises from the carelessness or wrong-doing of a fellow-servant, or any other cause, he should lose no time in informing the proper authorities thereof, and steps should at once be taken to remedy any defects that might be found to exist.

The owners of premises or their delegates would do well to look through the whole of their building occasionally to see that their employés take proper care to prevent a fire, and remind those persons that it is a part of their *duty* to protect the property from a calamity which, if it should occur, is almost certain to entail a loss upon all who obtain a livelihood in connection with the establishment; and these are not the only persons that may suffer, for the proprietor himself, in the majority of instances, is a heavy loser when his property is destroyed; property which no amount of monetary insurance can replace, and a business is often thus either completely ruined, or for a time crippled, and much inconvenience is caused.

SECTION II.

CONCERNING THE PRESERVATION OF LIFE FROM FIRE: AIDING ENDANGERED PERSONS TO ESCAPE FROM BURNING BUILDINGS.

The general practice of making a periodical payment to the fire insurance companies with a view to meet the pecuniary loss which might result from a conflagration, coupled with the adoption of strong rooms and iron safes, secured by bolts, bars, etc., in which to protect valuables from the action of fire, may be taken as an indubitable recognition of the possibility that a fire *might* occur and make havoc among our worldly goods, and it appears almost incredible that in this respect property should be placed before life; for while every precaution is taken to secure the safety of the former, the latter is invariably left exposed to the risk of irretrievable loss.

It is an astonishing fact that but very few persons give serious consideration to the possibility that an outbreak of fire might occur after they have retired to their cozy beds, and, during their slumbers, seize upon the ordinary means of descent and prevent their

reaching *terra firma* by the staircase they had but a few hours previously ascended; and yet, in the majority of dwellings, such a calamity would endanger the lives of all those persons who should happen to be on the upper floors.

It is not in dwellings alone that human life is jeopardised, for a very large number of business and other premises are constructed and furnished in such a manner that the chances are ten against one that many of the employés would be able to effect a safe retreat from the smoke and flames of a fire which might break out at any moment in one or other of the departments.

This question is a highly important one, and certainly deserves far greater attention on the part of both heads of families and employers of labour than it has hitherto received; for the omission to provide against a disaster which may come sooner or later amounts to a serious disregard of human life, which should at all times be held at paramount value.

In every instance in which there is a possibility that the ordinary ways of exit might be rendered impassable on the outbreak of fire, there should be no delay in providing suitable fire escapes or other means by which the whole number of persons in danger could get to a point of safety within a very few minutes of an alarm, and these measures, when furnished, should be maintained in a thoroughly efficient

state, so as to be immediately available at the time of an emergency.

The provision of means of escape from fire should, above all things, be of the most suitable and reliable description, and approved by a person versed in all the intricacy of fires, and no measures should be relied upon which would be reasonably likely to fail at a critical moment.

Doors or other openings to roofs of buildings should be easily accessible by a step-ladder at all times kept near thereto, and removed under no pretence for any other purpose; but before escape to the roof is relied upon, it should be ascertained that there is access to a further point of safety in the event of the flames passing through the roof of the building in which they have maintained their hold.

Iron balconies, ladders and bridges, rope ladders, portable fire escapes, canvas shoots, or other suitable appliances should be provided according to circumstances, so that persons may readily escape through the windows or other unusual means of exit from a building. Many disastrous calamities have shown it to be unwise to depend upon public fire escapes for the rescue of persons in imminent peril; in numerous instances loss of life would have been prevented had a timely provision been made, and, on frequent occasions, a common rope could have been successfully used if one had been at hand.

In many large towns, public fire escapes are judiciously placed over the area, as in London, which are in charge of firemen by night, who, with a little assistance, are ready to run the machine to the scene of a fire and gallantly endeavour to rescue any lives that may be in danger, and within reach; but while these measures are effective in some respects, they are incomplete and sadly wanting in others.

During the day the public fire escapes are invariably "laid by," and are not nearly so readily accessible in an emergency as is the case at night. Frequently they are under lock and chain, and at times placed in such a position that the strength of several persons and a delay of many minutes would be necessary for their removal, and here we have another illustration that the security of property is looked to more than that of life, for while these life saving measures are almost unheeded by day, the fire engines and firemen are ready for immediate action at all periods, be it day or night.

In vindication of these arrangements it may be said that the majority of fires have their origin while the largest number of the population are helplessly slumbering, but it should not be overlooked that during the day there are quite as many, and it may be said more, persons on the upper floors of buildings of almost every kind; certain it is that in thousands of business premises the lives of a considerable number of persons

would be exposed to injury or entirely lost if a fire occurred during the day, whereas at night the population are more equally distributed. Then, again, while numerous dwellings are undoubtedly not as fully occupied by day, the aged, helpless and younger members of the community are left without protection, owing to the absence of the parents and natural guardians, who are obliged thus to leave home in order to earn a livelihood for them.

The great elevation to which buildings are being carried will need consideration sooner or later, for the public fire escapes as they now exist cannot be made of use to rescue persons from the upper floors of such buildings as are of a greater height than from 45 to 60 feet, and therefore those who build or own lofty structures should undoubtedly make such provision as would enable the occupants of the upper floors to escape independently of outside assistance in the moment of peril.

Indeed, it is a question whether Government should not make it imperative for owners, tenants, or managers of factories or workshops, hotels, tenement houses or buildings in which rooms or floors are sub-let, schools, colleges, hospitals, workhouses, asylums, etc., to provide sufficient means of exit and permanent fire escapes. There should be a searching investigation into this important subject, for the heedlessness displayed in this direction amounts, in many instances, to a serious trifling with human life.

Upon the occurrence of a fire it is indispensable for every endangered person to preserve a calm presence of mind, and if every adult were to occasionally ponder over the circumstances in which he might be placed by such a calamity, considering the possibility of a fire to occur under various conditions, and impressing upon the mind such actions that could safely be taken, it would be likely that when a fire does actually occur the movements which were previously deemed essential will be remembered, and the imperilled person will be better prepared to act with composure. Every person should be thoroughly acquainted with the various means of exit which would be available in an emergency in the building in which he resides or is engaged, and profit will frequently result from a timely examination of adjoining or neighbouring premises in order to ascertain the danger of a fire communicating from one building to another.

In the event of a fire it should be remembered that all doors and other openings should be kept shut as close as possible, so as to exclude air and retard the progress of the flames from one room or floor to another, and when no other means are available, blankets or other articles torn or cut into strips and tied together might, when secured to a fixture or large piece of furniture, enable a person to slide, or lower others from the window to the ground.

When it is probable that persons may jump from

an upper storey, the on-lookers should obtain a strong sheet and hold it firmly about three feet above the ground, ready to catch those who jump, and a sheet thus held by from six to ten men would, in many instances, prevent serious injury to those who might otherwise be killed or permanently maimed.

Smoke is lighter than air, and therefore ascends, so that in numerous instances a person may breathe freely by crawling on the hands and knees and keeping the mouth near the floor while in a dense atmosphere; suffocation may be prevented by covering the mouth and nostrils with a towel, handkerchief, stocking, sponge, or other porous article, not too thickly folded, and when possible moistened with water. On retiring to rest, each person should place a handkerchief under the pillow.

A person, whose apparel has ignited, should immediately lie down and roll over on the flame, or if possible tightly wrap any loose coat, rug, or other suitable article around the burning portions, as if a person thus endangered remains upright or moves about, the current of air will fan and augment the flames.

The inflammability of cotton, woollen and linen fabrics is greatly reduced if washed in a solution of chloride of zinc, alum, or tungstate of soda.

When a person has received a *burn* or *scald*, water should on no account be applied to the injured parts,

but wadding saturated with linseed oil should be used as soon as possible. Lime water and linseed oil mixed in equal proportions make a good lotion for injuries of this kind.

When removing the apparel of a person, great care should be taken to prevent rubbing or stripping the skin from the injured parts of the body.

In the event of a person being rendered *insensible* from the effects of smoke, cold water should be thrown on the face, or the person's face turned downwards, resting upon the arms, and pressure applied along the back and ribs, after which, the body must be rolled on the side, and then face downwards, again and again, until respiration is restored, and then the body should be placed in a warm bath.

When *horses* in a stable are in danger by smoke or fire, their removal will be more easily accomplished by first covering their mouths, nostrils and eyes, and if time will permit, harness should be put on them as if they were going to their usual work; it may be remarked, that horses are exceedingly difficult to remove if they are allowed to see or smell fire or smoke, and it is therefore desirable that no time should be lost in rescuing them upon the outbreak of a fire.

SECTION III.

THE PREVENTION OF OUTBREAKS OF FIRE FROM RESULTING IN EXTENSIVE AND EXPENSIVE CONFLAGRATIONS.

The diurnal records of destructive conflagrations furnishes ample proof of the negligence of the populace in omitting to keep their property in a proper condition to guard against fire and the lack of preparation to confine and extinguish it while in an incipient state.

The loss which this country sustains every year is more than sufficiently enormous to demand that, in the interests of the community, the Government should direct its attention to the promotion of better security of life and property from fire throughout the kingdom, as by far the most prominent cause of the destructiveness of fires is the want of sufficient Legislative measures to prevent the erection of badly constructed and dangerous buildings, which are sure to be entirely consumed if a fire occurs and is not snuffed out at its starting, or liable to fall a shapeless ruin and imperil the lives of any persons who may be in them at almost the first touch of the destroying element.

Insurance companies, architects, builders and others could do much to improve the existing state of things; the former, by acting justly towards those who construct good buildings, and adopt precautionary measures against fire, and who deserve the benefit of specially low rates, in consideration of their comparative security from a conflagration: while on the other hand, they should charge high rates of premium for the pretentious shells and dangerous structures in which the possibility of a fire is disregarded; and the latter, by exercising increased endeavours to build up premises in such a manner that an outbreak of fire may not have its origin through some fault of construction or fitting, as well as to reduce the liability of a fire to rapidly spread from one floor or department to another before time has been allowed for steps to be taken to combat with it. It is true that insurance offices are gradually adopting the policy of rating risks as they find them, but this must be attributed to the keen competition which exists among them, and not to any free action of their own, for it is an admitted fact that a conflagration brings increased business to many professions and trades.

In the minds of persons generally, and indeed of many practical men, there appears to be a considerable amount of confusion in determining between materials which are indestructible by the action of fire and those that are incombustible, and this has been

frequently and amply demonstrated by the unfortunate collapse of buildings which were *supposed* to have been *fire-proof.* Over and over again I have been told by business men that their premises are "fire-proof," when but a cursory examination has shown how utterly erroneous their opinion has been, and their confidence sadly misplaced.

Thousands of pounds sterling are annually wasted on so-called fire-proof buildings for want of an efficient knowledge to determine on those constructional materials that will not be debilitated, decomposed, or consumed when acted upon by fire or great heat, or which cannot be expected to serve as additional fuel to the flames, and those which are capable of resisting the action of intense heat without change; and assuring as may appear the claims which are advocated by various patentees of "fire-proof" construction, it is a well ascertained fact that while some of the systems will retard the progress of a fire for a time, there are only a few of them that can completely resist the continued action of the heat and other circumstances attending a conflagration, and therefore the same precautions should be adopted to prevent and extinguish fire in a building which is said to be fire-proof as in any other.

The number of fire resisting materials available for constructional purposes is very limited, and it depends in a very great measure upon the manner in which

they are used whether they will serve their intended purpose or not.

Iron and other metals, when heated, become soft and yielding, and capable of being easily bent, while cast iron is extremely brittle, and if touched with water whilst in a heated state, will crack and fly to pieces, so that these materials will not resist fire unless effectually encased to prevent heat and water affecting them.

Solid cast iron columns will stand heat better than hollow ones, and as they occupy less space they might be easily protected with a thick coating of concrete, cement, or plaster, without taking more space than hollow columns of the same strength would do.

Iron girders and joists assist in the destruction of buildings, as their expansion and contraction will thrust out or pull down the walls.

Among the great variety of *stones* there are but a few that can be relied upon; Portland and other limestones are readily calcined and converted into quicklime by the expulsion of its carbonic acid under the action of heat, and staircases and landings formed of such material are more dangerous than if constructed of timber, because they are very liable to collapse at an early period.

Many flagstones will split in pieces; and granite is not so fire-resisting as its igneous origin would lead one to suppose, but it is capable of sustaining con-

siderable heat unless suddenly acted upon by water while hot. *Slate* being an argillaceous stone will exfoliate and fly into fragments when heated.

Some good building stones, composed of particles of sand agglutinated and known as the "grits," will resist intense heat, and many kinds of artificial stone are more fire-resisting than most of the natural ones.

Concrete may be classed as an artificial stone, and the materials used with the cement should be either sandstone, gravel, pebbles, flints, broken brick, sifted ashes or burnt clay. All the harder kinds of brick and tile may be taken as generally capable of resisting fire when used as walls or in arched floors, but the softer kinds crumble when touched by water while highly heated.

It is a question whether *timber* and *brick* are not under certain conditions the most reliable of all materials, for many of the harder kinds of timber are very difficult to ignite, and when used of considerable thickness the action of heat merely chars the outside, and seldom penetrates deeply into the wood, while there is no danger that the water used for extinguishing a fire will cause either floors, joists, or uprights to fly and give way.

It is only when timber is soft and cut up into thin slices that it readily ignites, and adds fuel to the fire, but even this may be prevented, for wood may be rendered incombustible by Sir William Burnett & Co.'s

and various other processes, among which may be named the following:—

Soak the timber in a solution of 1 part of silicate of potassa to 3 parts of water for twenty-four hours, and after being dried for several days, again soak it in this liquid, and again dry it; then paint it with a mixture of 1 part of cement and 4 parts of the liquid above described. Three such coats of paint should be put on, each being thoroughly dried in its turn, and as the paint quickly dries and hardens it should not be prepared in large quantities at a time. Wood thus treated is not only incombustible but will not decay underground. A similar result may be obtained by coating woodwork several times with solution of silicate of soda, after which it may be finished off with a mixture of this solution and sufficient common whiting to make it about as thick as ordinary paint; a solution of alum washed over woodwork will also render it fire-resisting, while the same process may be applied to the clothing of individuals who may perform on the stage, where there is a chance of their getting in contact with gas flame.

Ordinary dwellings may be rendered sufficiently fire-proof by avoiding the use of materials that readily take fire, such as thin joists, rafters, and light stairs and balusters; by filling up the space under the staircase, between the wooden treads and plaster ceiling; by using iron balusters to the stairs; avoiding

hollow lath and plaster or match-boarded partitions, or having them brick-nogged so as to leave no hollow spaces; by having the floor-boards of hard wood, of good thickness and tongued, instead of deal. But it is not in buildings of this class that the great fires occur, and in which it is so highly desirable to guard against the possibility of a fire making a strong headway, but in large warehouses covering extensive areas of ground, and in which thousands of tons, representing as many thousands of pounds sterling, of flammable goods are stored. These buildings require a very different mode of construction to render them capable of withstanding the tremendous heat that will be generated if a fire occurs in their great rooms, as well as to resist the impact of falling bodies.

In the first place, the walls of such buildings should be made much stronger than is actually necessary for the ordinary requirements of the business intended to be carried on in them, and for this purpose good concrete would be a better material than brick; while in either instance it is highly important that all front, side and cross-walls should be firmly tied in or bonded throughout with iron hooping or otherwise, in order to prevent settlements and cracks, or one wall parting from another.

Concrete might also be used for the staircases and landings, iron hooping, or wire, being embedded therein to prevent risk of fracture; the steps cast in

moulds and built into the walls on both sides, and not allowed to hang over on the outer side. If stone is, however, used for such purposes, it should be hard grit and free from laminations; but steps may also be made of fire-clay, terra-cotta, or artificial stone, which are both durable and fire-resisting.

For warehouses of large size it is almost impossible to dispense with the use of iron girders to carry the floors, but these should be entirely covered up and protected so as to prevent the products of combustion from reaching them. A good way to do this is to lay concrete, several inches thick, flush with the underside of the joists or girders, and then cover the whole with plaster; the floors above could then be laid in any way that is required, because the concrete below, if good, will effectually check any fire from passing through.

A concrete made of Portland cement or blue lias lime, with gravel ballast or broken hard brick, in the proportion of one part of the former to four or five of the latter, sets quickly and becomes as hard as stone.

Independently of the fire-proof condition of floors constructed in the manner described, there are other advantages to be derived from this mode of structure. In the first place, the access of rats and mice from one part of the house to another would be almost, if not wholly prevented, as the spaces

usually left between the flooring of the room above and the ceiling below, the bad and hastily-mixed mortar commonly used in buildings, the imperfect manner in which it is frequently laid between the bricks or stones of the structure, and the hollow, unplastered interval left between the skirting board and the wall, afford ample opportunity for these vermin to make their way from basement to attic at pleasure.

If it is found necessary to support the girders in the middle, hollow iron pillars should be avoided. They should either be of solid iron, or what would be better, fire-bricks, moulded circular and built up into a round pillar. If cast iron is used it should certainly be protected by a covering of fire-clay, brick, concrete or plaster.

It is not infrequent that the falling in of the roof leads to a total destruction of the building in which a fire occurs, and therefore the ceiling of the top floor should be made fire-resisting, or independent of the roof above it, which may then be made of any ordinary material, for if the roof took fire, it would not be communicated to the floor below, provided a strong fire-resisting ceiling intervened.

The iron girders which carry the floors should not be built into the wall, which is weakened by so doing, but rather supported on corbels of fire-brick or hard grit stone; in either plan, however, the ends

should be allowed full play, so that in case of any expansion they will not thrust out the walls.

When an *iron bressummer* is introduced to carry the weight of a wall above, it should be cased with timber, well plastered over, or otherwise protected to prevent the heat reaching the metal in time of fire, as any twisting or yielding of the bressummer may seriously endanger the superstructure, and probably lead to its falling upon those persons who may be engaged in extinguishing the fire with fatal results.

As concerns open *elevator* or "*lift*" *wells, light shafts* and *stairways,* I may say that these are the most disastrous features in modern buildings, and should therefore receive important attention. The two former are the most dangerous, because they are continuous vertical openings, while the latter may not be continous, and may offer some obstruction to direct upward draughts.

The dangerous nature of elevators or "lifts," as they are usually called, has become so much more evident lately than it was a few years ago, because, until within about twelve years past, the hoistways consisted of square openings in the floors, through which a rope and hook were dropped from a windlass at the top, the windlass being worked by a rope passing over a wheel. These floor openings commonly had trap-doors of wood, hinged on one side, so that they could be opened and closed with facility. The modern

elevator or lift, which has been supplanting these inconvenient hoists, consists of a moveable platform, counter-balanced by weights, and operated upon by hand, steam or water power. The guides, safety appliances, counter-balances, and additional ropes required by this improved machinery, occupy so much space in the well-holes, that the use of trap-doors has become extremely inconvenient, and in some cases impossible; hence, where before the traps were closed at night, there are now none to close, except in a few instances.

When lifts are put in, trap-doors disappear immediately, hence we constantly hear of increasing destructive fires. What is demanded by the present exigency is, that not only should some provision be made for closing these dangerous openings, but that human agency may not be depended upon, and that the power so skilfully used to raise and lower lift cages, should also be applied to open and close traps or valves automatically.

The whole of the sides of a lift well should be built up of brickwork, and not light match-boarding, as is so frequently the case, and the opening on each floor should be fitted with fire-proofed iron or stout hard wood, close fitting doors, which should be shut at all times when not required open for business purposes, because no person knows the moment when a fire might take place, and if they are not closed, as a

general rule, they are almost sure to be forgotten when a fire does occur, and the lift well may serve as a pitfall for the fireman as he is groping his way through the smoke, and prove too a disastrous flue for conducting the flames from one room to another, and thereby place the chance of saving the entire building beyond all possibility.

Light shafts are fully as dangerous in conducting fires as lifts, when there are unprotected windows or other openings in them, and it is safest, therefore, to provide iron or stout hard wood close fitting doors, to cover such openings, because, although glass in windows cannot be made to take fire, it breaks into pieces as soon as heat reaches it, and will liquefy at a moderate temperature.

In large business structures, the floor area should be sub-divided into compartments; the size of such compartments will vary according to the use required of the building, but the smaller they are the better from a fire protectional point of view. The divisions should be made of walls of brick or other fire-proof material, and all the openings which it is necessary to have therein should be fitted with fire-proofed iron or stout hard wood close fitting doors.

The proper construction of *fire-proof doors* is a very important subject, the neglect of which has been the cause of numerous fires extending from block to block, until the whole series are destroyed.

Great confidence is frequently placed on so-called fire-proof doors, which would undoubtedly be found utterly inadequate and unsuitable for retarding the progress of a fire, even for a reasonable space of time, and their cost has, in consequence, been a sheer waste of money, while in other instances, the provision that is made may be likened to the placing of a strong military force to protect one entrance to a fort, and leaving the ninety and nine other points of entry unguarded.

Simple plate-iron doors should never be relied upon to withstand the action of considerable heat, because by their expansion and warping they tear themselves away from their hangings, and if they do not fall down they will buckle and open in places so that the flames may pass between the door and its framing, or if this does not occur the heat may be conducted, by the heating up of the door, from the burning department to some inflammable goods or material which may happen to be located near it in another department, and doors of this kind when fixed in pairs are scarcely more reliable than if the second door was absent, because after one door succumbs to the action of the heat the full force of the fire is transmitted to the other. Then, again, iron doors are frequently fixed in such an unscientific manner that they allow the flames to pass them long before the door itself becomes materially affected, and this is especially the case when the door is not fitted closely to its frame.

One door only is required to an opening, provided it is formed of stout double plate iron or steel, with a space for the working of the bolts, and a thickness of three or more inches of reliable non-combustible and non-conducting composition or material all over between the plates, securely stiffened and hung in a close fitting frame firmly built into the wall at least four and a half inches back from the face of the reveal, so that heat can have no material effect upon the fixings, and the heads and sills of these doors should be built of either hard brick, concrete, or grit stone; under these conditions, if the door became red hot on one of its faces, no injury should happen to the other side, and therefore the fire would have but little chance of passing it.

The doors of strong rooms and safes should be made up with fire-resisting material, similar to the divisional doors described, and the top and bottom and side walls constructed of thoroughly good and solid fire-resisting materials.

It may not be out of place to mention that many strong rooms and safes cause damage to their contents by their interior becoming damp in consequence of the moisture given off from the alum which forms one of the fire-proofing ingredients, and it is therefore necessary that parchments and deeds should be placed in additional air tight boxes, in order to preserve them from injury.

Wherever iron doors are fitted some responsible person should be deputed to securely close them between and at the expiration of business hours, and it is advisable, indeed, that every door, whether iron or otherwise, should be so closed, because I have known many instances in which an ordinary close-fitting wooden door has retarded a fire for a considerable time and effected a saving of thousands of pounds worth of property.

All iron doors and iron revolving shutters should be so arranged that they may be easily opened on the arrival of firemen, and it may be well to add that revolving shutters are not so good as hinged doors, because after they have become expanded and distorted by heat it is rarely possible to wind them either up or down.

The great secret of the destructiveness of fires lies not only in the combustible construction of buildings, but also in the rate at which they are allowed to spread before the arrival of fire engines and other means being employed to subdue the flames.

One cannot imagine a sight of more despicable inaction than a large building in flames, surrounded by numbers of horrified spectators, helplessly looking on, the premises meantime being rapidly consumed before their very eyes, because no fire extinguishing measures are at hand available for use.

Fires extend in more than geometrical progression;

the first spark can be easily extinguished if means are at hand, and promptly used, and even after it has blazed up freely for several minutes small measures would suffice, but when fifteen to thirty minutes (in less than which time no aid from *public* fire extinguishing appliances could be expected under almost any circumstance or in any locality) have elapsed, the flames will, in all probability, have obtained sufficient hold to resist all efforts to subdue them, until they have, perhaps, destroyed an entire block or more.

Three-fourths of all fires could be snuffed out at their commencement if the appliances were only at hand with which to combat the fire in its comparative infancy, and it is therefore desirable that every person having property which is combustible should be impressed with the advisability of giving a timely and careful consideration to the question of provision against fire, in order that they may be prepared to meet the hour of danger.

Death and fire have all seasons, and well would it be for us all if we were always ready for either or both.

Long immunity from fire is apt to beget a feeling of security, and the carelessness resulting from over-confidence has been the means of destroying many valuable properties. It is always in the first stages of a fire that strictly efficient action is necessary, and here it is worth a thousandfold more than can be any efforts when a fire is once thoroughly started.

It is said "an ounce of prevention is worth a pound of cure." A disease once rooted may require years to eradicate, but when the medicine is so cheap, and the disease superficial, the latter may be easily destroyed in its incipiency.

In all establishments there should be means for extinguishing fire on every floor '*Semper Paratus.*' There are numerous instances, even in premises in which the business carried on is of a most dangerous nature, where not even a bucket of water is *ready* to cast upon an outbreak of fire, and where, while the alarm is being given, and the firemen are travelling to the scene, the work of destruction would undoubtedly proceed, and by the time extinguishing power arrived the premises would be past being saved. "*Tempus edax rerum.*"

The simpler the appliances are the better, but they should be to the purpose. A bucket full of water ready to hand and used with energy would in most cases be sufficient to prevent a conflagration, but when a bucket has to be searched for, a convenient water tap found, the bucket filled and carried to the scene of the outbreak, it is only reasonable to expect that such small measures will be ineffectual to the extinction of a fire, which, by this delay, has been permitted to make headway.

To persons who may be inclined to procure fire extinguishing appliances, it is necessary to give a caution against adopting those which are not the best

of their class, and offered or provided by a firm of experience in this business, because too great faith at present exists in numerous toys and inventions which are called by so many inviting names and certified to do such wonders, but which most assuredly prove delusions and snares in the moment of peril. In such a matter, whatever is worth doing at all is certainly worth doing well, and in the long run, the most reliable appliances will cost no more than the most faulty, while the security afforded in the former instance is, as a matter of course, a thousandfold greater than can be the latter.

The utility of chemical extincteurs lies in the *pressure* which is obtained by the generation of gas within the cylinder and furnishes the power to eject the water upon a fire. This water may carry a small proportion of carbonic acid gas along with it, but as it quickly becomes absorbed by the atmosphere it is necessary for the nozzle to be taken to within a few feet of the flames, in order that it may have effect, but in the majority of instances the stream from such a machine possesses no greater power to extinguish a fire than if water was simply forced on with compressed air or any other force, and as the extincteurs gradually lose their power and become useless after being in operation for two or three minutes, they should only be relied upon for very small fires. From the earliest ages water has been considered as

the great means provided by nature to act as the antagonist to fire, but attempts have been made at various times to increase its efficiency by mixing with or dissolving some chemical substances in it; but however well such a proceeding may have turned out when tried on a small scale as an experiment, upon a fire made up *especially* for the purpose, well arranged to give the uninitiated public results and proofs of all that can be advanced in its favour by interested persons, a few moments reflection shows that it would be both costly and inadmissible in practice, and gives such strong proof of the inapplicability of such plans to the present circumstances of fires in buildings, etc., as could not fail to be seen had the "demonstration" been made upon a thorough—I might almost say "natural"—fire and attention paid to the circumstances connected therewith.

Upon each floor of every building, from the private dwelling to the extensive manufactory or warehouse, there should always be a supply of buckets *full* of water ready to be used on the first sign of a fire, and it is well to have, in addition, a hand fire pump of proper construction, by means of which a person could, unaided, pump a stream of water high enough to strike the ceiling of each floor with considerable force, and thereby command such points as would be inaccessible by water thrown from buckets on account of smoke, heat, height, or other causes.

In the case of large buildings, where a good supply of water at sufficient pressure can be obtained from elevated tanks, which are already, or can be, fixed, or from the water company's constant high pressure main, the best plan is to convey it through iron or other hard metal pipes (not lead) to the most suitable positions—probably on each floor—and there fix hydrants with hose and fittings so arranged that they may be brought into efficient use in a moment, but in many instances the provision of buckets as well as hand fire pumps would also be advisable.

For buildings or premises remote from a high pressure water supply, as in the case of country mansions, etc., a manual or steam fire engine to utilise the water from ponds, wells, etc., might be necessary, but the size and description of the engine and quantity of hose and appliances must depend upon the circumstances attending each case.

Where the means of earning a livelihood of a large body of employés would be cut off, or surrounding property imperilled by a destructive fire, there can be no excuse for an omission to take the precautions necessary to reduce the risk of such a calamity as far as possible, and the question of expense is an insignificant plea to raise in a matter of this kind.

With the best of appliances, however, discipline and drill on the part of the hands in all large buildings is of prime importance; everyone should know how to

act if a fire occurred, where to go, what to do, and the things especially to be avoided, and for this end the employés should occasionally be called upon to cope with an imaginary fire.

The appliances should be maintained in an efficient state, and in time of frost especial attention should be directed to the storage of water, because the chances of fire at that season are materially increased, and the demand upon the services of the public fire brigade may also be expected to be large in consequence, while on the occasion of a snowfall the difficulty both of transmitting a fire engine to the scene and the ultimate discovery of fire plugs and getting to work are likely to cause unusual delays in fighting the enemy unless private precautions have been taken.

Whenever the authorities of premises desire to make their building proof against a serious fire, they should have their property fully surveyed by a fire engineer who has had extensive experience in such matters, and who should be requested to furnish a report of what he thinks necessary to be done in order to give efficient security. The report so obtained could then be considered by the proprietors, their architect, engineer and builder, and a decision come to as to what can or cannot be carried out under the existing circumstances. Such a course would not only, in many cases, prevent a needless waste of money, but

also give the best assurance that whatever is done is likely to prove effectual.

It is also an admirable system to secure the services of a competent fire engineer to periodically visit any building for the purpose of examining into all matters pertaining to the liability of a fire occurring from any cause, and report anything that may seem to him to need attention, and such suggestions as he may think necessary to make for the better protection of the property. Such a system is much needed in many of our best equipped buildings, where, through mere neglect, combustible rubbish is allowed to accumulate in dangerous localities, etc., etc., while the fire buckets are left empty or carried away for other uses, the water-mains without water, and hose kept for years tightly coiled and carefully stowed away until it becomes forgotten, or so decayed or adherent as to be practically useless for want of a little periodical attention.

Owners of large premises should occasionally call upon their employés to cope with an imaginary fire, and then many of them will undoubtedly find means of improving their present system of protectional measures, elaborate as they may now think them to be.

There are various devices for enabling the rise of temperature accompanying an outbreak of fire at a particular place in a building to sound an automatic

alarm, but they are uncertain in their action, and I have never known one to have been the agency for giving information in the case of an actual fire.

It is true that in instances where special fires have been made to test an apparatus it has seemed to prove satisfactory, but the results obtained upon the occasion of favourable experiments cannot be looked upon as a criterion on which to found any recommendation for the general adoption of such measures.

Next to pouring water upon a fire the best thing to do is to keep it smothered and confined; so long as it is not well fed by air it will not extend itself very rapidly, and this should be strongly impressed upon the mind of every reader, because it is such an almost general practice for uninitiated persons to commence pulling down shutters and opening doors and windows as quickly as possible after seeing a fire and before appliances are at hand to attack the fiery element, and as these steps permit currents of air to fan the smouldering embers into full blaze, it is not the fault of those thoughtless individuals if there is not a speedy destruction of the premises.

When the upper part of a building is alight, and time and the number of persons at the scene will permit the performance of salvage operations, everything upon the floors under the fire in danger of being damaged by fire, smoke or water, should be removed or covered up with damp carpets, sheets, or

other suitable coverings, and in instances where it is not likely the fire will extend it is better to cover goods where they are, than to remove them, except that if a good central position in any room or floor can be found, it is wise to make one good sound stack, and cover it well, rather than to have several parts all requiring attention, and the surplus water should be collected as far as the means at hand will permit.

As soon as the goods are secured on the first floor under the fire, care should be taken to prevent the water passing through and damaging the floor next under that which has been attended to, and a deal of good may be done in this direction if sufficient help is at hand while the upper floors are being cared for.

If sawdust is at hand it should be thickly strewn over the floor, as it will increase in bulk when wet, and by filling the seams, do much to prevent the water passing through boarded flooring.

If the place on fire is large, much good may be done by making a breach in the goods, and thereby cut off communication even before the fire-brigade are ready to work; such steps may also improve the thoroughfare for the firemen to the position of the fire.

If the fire is upon a lower floor steps should be taken as soon as the flames are being got under to open the doors and windows upstairs so as to give

the smoke and steam free facilities to pass out of the building.

If the windows, or an imperfect wall of an adjoining house, should be in close proximity to that on fire, it is a good course to cover the openings with blankets or sheets kept well wetted. When property has to be removed from a building, care should be taken not to do unnecessary damage, and it may be remarked that at almost every fire, property from adjoining houses is indiscriminately removed and unnecessary loss incurred.

Whenever goods are removed, they should be guarded against wanton damage, and taken to a place of safety against theft.

SECTION IV.

USEFUL INFORMATION CONCERNING ARTIFICIAL ILLUMINATIVE AGENTS AND THE ACTION OF HEAT.

The materials ordinarily furnishing artificial light during the act of combustion are oils, wax, tallow, spermaceti, paraffin, rock oil, and gas from coal, resin, wood and other organic matter, and the extraordinary light-giving agents are oxygen and hydrogen gases, burning and directed on to a ball of lime; the combustion of the metal magnesium in air, or of phosphorus in oxygen gas; the Voltaic battery, in which zinc is consumed and two charcoal points ignited by the current of electricity; the magno-electric machine, worked by steam-power, and, therefore, consuming coal in place of zinc, to produce the electric light. In the ordinary light-giving substances the predominating elements are carbon and hydrogen, and when any of them are subjected to destructive distillation, these elements unite and form the important compounds of olefiant gas and light carburetted hydrogen; a number of other compounds being also produced when coal is used.

It is stated that coal gas may contain from 25 to 50 per cent. of hydrogen gas, 35 to 52 per cent. of light carburetted hydrogen, and from 3 to 20 per cent. of olefiant gas, and other hydrocarbons mixed with gases, such as carbonic oxide, carbonic acid, cyanogen, ammonia, oxygen, nitrogen, some aqueous vapour and sulphur compounds. Out of this complex mixture the only gases required are the compounds of carbon and hydrogen; and hence tallow, oil, wax, paraffin, turpentine, etc., used in candles and lamps, which are miniature gas works, yield a gas purer than the heterogeneous one derived from the distillation of coal.

In a candle or lamp the retort is the wick, and this when first lighted burns down until the heat reaches that part which is saturated with the tallow, composite, wax or oil, and at this point destructive distillation commences; the heat from the increased combustion now melts more of the solid material, or by capillary attraction draws up more oil, as the case may be, which is decomposed in its turn and furnishes fresh gas for combustion.

In the above case the gas is generated and burnt directly it is produced, while with coal gas the generating process is carried on at some fixed point, and the gas thence conveyed through pipes to the consumers, but whenever any undue pressure exists in the gas distributing mains, the gas does not properly consume itself, and therefore the light given off is not at all in

proportion to the quantity of gas consumed, unless an efficient governor is affixed to the supply pipes.

The consumption of gas is much more complete, and consequently the danger of unconsumed or partly burned gas escaping is much diminished, when a globe or chimney surrounds the flame and is surmounted with a piece of mica or metal fitted to give an air space between it and the globe or chimney.

The analysis of coal gas shows that when the relative proportions of inflammable gas and air are as one volume of the former to five volumes of the latter, the mixture is not explosive; but if the quantity of air be gradually increased from five to ten or even twelve volumes, the mixture on meeting an artificial light detonates with increasing violence at every additional volume of air up to the point of saturation, and as a more familiar illustration of these phenomena, we may suppose 100 cubic inches of coal gas to be mixed with 500 cubic inches of atmospheric air. The mixture will not be explosive, because it will not contain a sufficiency of oxygen to support its inflammability—500 inches of air containing only about 100 inches of oxygen—and 100 inches of coal gas requiring 200 inches of oxygen for its complete combustion. If, however, 100 inches of coal gas be mixed with 1,000 inches of air, the mixture *will* be explosive, since it will contain the relative proportions of the inflammable gas and the supporter most favourable to inflammability or explosion. We know that when

coal gas, or the fire damp of mines, is mixed with air, in proportions of one volume of the two former to any number of volumes intermediate between 5 and 10 of the latter, the mixture is explosive; but it is only so to a certain extent. When the proportions of air exceed 12 or 12½ volumes of inflammable gas, the mixture is not explosive—an excess of oxygen having, in this respect, the same effect as its deficiency.

Paraffin and rock oils are the best sources of light for domestic purposes; they are the cheapest, give the greatest amount of light, and, what is of still greater importance, they do this with the least development of heat.

Petroleum oil is in more general use than any other kind of artificial light-giving liquid, and but few things are known less about by the majority of persons. It appears in numerous forms and under many names, such as gasoline, naphtha, benzoline, kerosene and paraffin, all of which are the product of petroleum. These oils, when heated, should not evolve an inflammable vapour below 120° Fahrenheit, and should not take fire below 125° to 140° Fahrenheit. As the temperature in a burning lamp rarely exceeds 100° Fahrenheit, such an oil would be safe; it would produce no vapours to mix with the air in the lamp and make an explosive mixture, and if the lamp should be overturned or broken, the oil would not be liable to take fire. Paraffin oils, at ordinary

temperature, should extinguish a match as readily as water, but as there is much competition in the selling of these liquids, there is a strong inducement to refiners to turn the heavier portions of the naphtha into the paraffin tank, so as to enable it to be retailed cheaper, or a higher profit reaped. In this way, the volatile naphtha or benzoline is sometimes mixed with the paraffin, rendering the whole highly dangerous.

There are two distinct tests for oil, the flashing test and the burning test. The flashing test determines the flashing point of the oil, or the lowest temperature at which it gives off an inflammable vapour. This is the most important test as it is the inflammable vapour, evolved at atmospheric temperatures, that causes most accidents. Moreover, an oil which has a high flashing test is sure to have a high burning test, while the reverse is not true. The burning test fixes the burning point of the oil, or the lowest temperature at which it takes fire. The burning point of an oil is from 10° to 50° Fahrenheit higher than the flashing point. The two points are quite independent of each other; the flashing point depends upon the amount of the most volatile constituents present, such as naphtha, etc., while the burning point depends upon the general character of the whole oil. One per cent. of naphtha will lower the flashing point of an oil 10°, without

materially affecting the burning test. The burning test does not determine the real safety of the oil, that is, the absence of naphtha. The flashing test should, therefore, be the only test, and the higher the flashing point the safer the oil.

None of the petroleum products are explosive *per se*, nor are their vapours explosive under all circumstances when mixed with air. A certain ratio of air to vapour is necessary to make an explosive mixture. Equal volumes of vapour and air will not explode; three parts of air and one of vapour gives a vigorous puff when ignited in a vessel; five volumes of air to one of vapour gives a loud report. The maximum degree of violence results from the explosion of eight or nine parts of air mixed with one of vapour; but while great skill is required to make the proper combination to produce an explosion, accident frequently fills the place of skill with the highest success.

There is not much danger in the use of kerosene or paraffin, if it is of the standard quality required by law, but at the same time petroleum is dangerous under certain conditions. When oil is heated, it is more or less inflammable, and in fact, inflammability is only a question of the temperature of the oil after all.

Burning oils should be kept in a cool place, and always with care; of course, if a lighted lamp is

dropped and broken, the oil is liable to take fire, though the lamp may be put out in the fall, or the light drowned by the oil, or the oil not take fire at all. This will be the effect if the oil is cool and of high flash test. Few things are so generally carelessly handled as burning oils, and yet these liquids are usually such as should be treated with the greatest amount of caution.

The remarkable phenomenon which we call heat plays too important a part in nature to be overlooked in a work of this kind, and the following is therefore appended as given in the "The Building News":—

It is an *almost* universal law that bodies expand in volume as their temperature rises, and contract as it falls; and we find that water follows this law between the temperatures of 4° and 100°, so that the same weight of water which at 4° occupies exactly 1 cubic foot of space, or 1,728 cubic inches, will be found at 50° to occupy 1,749 cubic inches, and at 100° a space of 1,803in., the *rate* of expansion increasing with the rise of temperature. The contraction is also in an inverse ratio as the temperature falls, 1,728 cubic inches of water at 100° occupying only 1,656 inches at 4°. Here, however, the contraction ceases, for we find that as the temperature falls below 4° the water expands as much for each degree below as it did for each degree above 4°; consequently the temperature 4° is that at which water has its greatest density, and 1,728 cubic inches

at 4° occupy $1{,}728\frac{1}{4}$ at 0° or zero of Centigrade scale. At this point, however, a sudden change occurs, the liquid water becoming solid ice, and at the same time expanding instantaneously about 10 per cent. in bulk, so that 1,728 cubic inches of water at 0° are converted into 1,904 cubic inches of ice at the same temperature. The force developed by this expansion at the moment of congelation is the same as would be required to compress a given quantity of water by 1-11th of its bulk. Now the pressure of 15lb. on a square inch of water is found to produce a compression of 1-20,000th of its bulk, therefore the force per square inch required to compress it by 1-11th must be equal to

$$\frac{20{,}000}{11} \times 15, \text{ or } 27{,}273\text{lb.},$$

or about 12 tons for every square inch of surface. This, then, may be taken as the actual force exerted by the congelation of water, and as it takes place very suddenly, the effect produced by converting water in a closed vessel will resemble the blow of a hammer of 12 tons weight upon every square inch, so that we cease to wonder at the bursting of the strongest pipes if full of water when congelation takes place. Newly quarried blocks of stone, if exposed to frost, will be split to pieces by the freezing of the moisture which they contain. Blocks of slate are also rendered more fissile by the action of frost, and can be readily split into thin layers, but should a thaw follow the frost it will be found

very difficult to split them until a new frost sets in and restores the faculty of splitting. If, however, the blocks of slate are exposed to a succession of frosts and thaws, they become quite unsplittable. Mortar or cement joints which have been newly made, when a frost comes will be seriously affected by the freezing of the water they contain, and will fall to pieces.

The expansion and contraction of solid metals from an increase or diminution of their temperature is much less in quantity than in the case of liquids, being scarcely perceptible for moderate degrees of temperature. In some metals the change which takes place is much greater than in others, and is always more in proportion at high than at low temperatures; and if we increase the density of a metal by hammering or rolling, we find that its rate of expansion is also increased. The linear expansion of a rod of zinc 100ft. long, if heated from 0° to 100°, is 3·576in.; that of a rod of lead 100ft. long is 3·384in.; that of a copper rod 100ft. long is 2·064in.; while a bar of wrought iron 100ft. long expands only 1·464in., but if drawn into wire a 100ft. will expand 1·728in., and a bar of cast iron 100ft. long is increased by 1·356in.; one of untempered steel by 1·296in., but a bar of tempered steel is increased by 1·488in. A rod of glass expands about half as much as one of copper. The cubical or volumetric expansion of solids is in all cases three times the linear expansion. The force of expansion

being equal to that necessary to compress the body to its original dimensions, we are able to calculate the thrust which a bar of iron exerts when it is heated through 100°, and find that it amounts to 15 tons in a bar 1 inch square, and therefore, to a proportionally greater force in a larger mass. From this we see how necessary it is that a certain amount of play should be always given to ironwork when employed in large quantities in a building, especially where it is exposed to considerable variations of temperatures, as in roofs, bridges, railway structures, etc., otherwise the supports may easily be overturned by the enormous force developed in the expansion and contraction of the metal.

When a bar of cast-iron has been exposed continually for several days to a temperature above 900°, it will be found that when allowed to cool again it has not contracted to its former length, but that it has become permanently elongated, so that if its original length was 100 inches, it will now be found to have increased to about 101 inches.

Water is not the only liquid that expands on becoming solid, for we find that molten iron has the same peculiarity, and this enables us to cast it in moulds of the most delicate patterns, as in solidifying it expands and fills up every part of the mould. If we put a ball of solid iron, at any ordinary temperature, into a mass of the molten metal, we shall find that at

first it will sink to the bottom from its greater density, but that as it becomes heated it will get lighter in specific gravity, and will eventually rise and float on the surface as soon as it has reached its plastic state, or about red-heat, showing that the solid metal is of less density than the liquid iron. As soon, however, as the iron has solidified it begins to contract with the lowering of its temperature, and this contraction has to be allowed for in making the patterns for castings. Thus in passing from the temperature of about 1500°, at which it melts or solidifies from the molten state, to the average temperature of the air, it is found that iron contracts in length from 1 to 2 per cent., according to the quality of the metal.

From experiments which have been made in order to test the resistance to strains of iron at various temperatures, it appears that cast-iron beams attain their maximum strength at the temperature of melting ice, or 0^c of the Centigrade scale; and that if their temperature is reduced to $-9°$, their strength is also reduced by about one-eighth. On the other hand, if a cast-iron beam is heated to 100°. or the temperature of boiling water, the strength is reduced by about one-eighth; but if heated to redness, or about 900°, it loses one-third of the strength it had at 0°. This result shows how little reliance is to be placed upon this metal as a material for fire-proof building, as in case of a fire occurring which would heat the metal above

redness, the iron beams would give way under a load that they would easily support when cold.

Wrought iron plates appear to attain their greatest tensile strength at the ordinary temperature, or about 16°, and to lose one-fortieth of their strength if the temperature is reduced to −18°, or the zero of the Fahrenheit scale. If heated to 100°, the strength of a wrought-iron plate is reduced by about one-ninth, and by one-fourth when red heat is reached. Wrought-iron rods, however, would seem to be strongest at the temperature of 160°, losing one-fourth of their tensile strength when it is reduced to 16°, whilst at red-heat they lose above half of their strength. The resistance of some kinds of iron to strains is, however, affected in a much less degree by changes of temperature than other kinds; but in all the loss of strength is very considerable, as they approach the temperature of red-heat, which may perhaps be partly accounted for by the density being reduced, since that is generally proportional to the cohesive force. When wrought-iron is heated to about 1,300° or white heat, it becomes so soft that two pieces of it can be welded together by hammering, and the welded joint is then as strong as the metal itself when it becomes cold.

Steel is a variety of iron which owes most of its valuable qualities to the action of heat. When a piece of soft steel is heated to redness and then suddenly cooled by plunging it in cold water, it becomes very

hard and possesses great power of resistance to a crushing force, but is at the same time too brittle for ordinary use, as it will fracture at the slightest blow; but on being reheated to redness and allowed to cool slowly it regains its original softness and malleability. If the metal is now reheated to a temperature much below redness and then cooled suddenly, it becomes softened to a degree inversely proportional to the temperature to which it has been raised, so that by carefully regulating this temperature we can give to steel any required amount of hardness or softness, this process being called "tempering" the steel. By hardening steel within certain limits of temperature we increase its tenacity, but if heated to bright redness the tenacity is reduced. The process of hardening steel has also the effect of diminishing its specific gravity or density, since the material becomes permanently expanded in its dimensions; thus we find that while the specific gravity of unhardened steel is 7·9288, that of hardened steel at 11° is 7·6578. If, however, the metal is remelted, the specific gravity of the unhardened steel is 8·0923, which is reduced by hardening to 7·7647. The dilatation by increase of temperature is also greater in tempered than in untempered steel.

We are generally apt to regard iron and steel as good conductors of heat, which undoubtedly they are as compared with non-metallic substances, their conductivity

being about twenty times that of hard sandstone; but as compared with other metals, their conductivity is low, being only one-seventh that of copper and one-tenth that of silver. Their power of conducting heat is also less in proportion at high than at low temperatures.

Lead is a metal which has a very low fusing point as compared with iron, becoming liquid at 334°, and having a less density in the molten than in the solid condition, so that a piece of solid lead will not float in the molten metal, as happens in the case of iron. The expansion and contraction of lead by changes of temperature are considerable, for in being heated through 50° of temperature a sheet of lead 10ft. long will expand one-sixth of an inch in length, and will contract by the same amount in cooling, the force developed in this change of length being equal to 1,000lb. per square inch of section; hence arises the necessity of allowing it to have free play when laid as a covering of roofs, which are often exposed to quite as great a variation of temperature as that mentioned above.

The metal zinc has its character greatly modified by variations of temperature, an ingot of zinc being very brittle at ordinary temperatures, while if heated to 200° its brittleness is increased to such a degree that it may easily be reduced to powder. Between the temperatures of 100° and 150° it is, however, capable of being rolled into thin sheets or drawn out into fine

wire. The degree of malleability which zinc possesses depends also on the temperature to which it has been raised when in the molten state, the metal being more malleable if cast at a temperature very little above 412°, its fusing point, than when it has been heated to a higher degree. The effect upon zinc of rolling it is to harden the metal, and in order to render sheet-zinc available for building purposes, it becomes necessary to have it annealed at a low temperature; for if it is heated to a temperature at all near that at which it melts, it will become brittle again. Zinc that has been cast at a temperature only just above the fusing point, and then cooled rapidly, is found to have a specific gravity of 7·178; but if cooled slowly it is less dense, and has a specific gravity of 7·145. A different result is, however, obtained if the metal has been heated to redness before casting, its specific gravity when cooled rapidly being in that case only 7·109, or if cooled slowly, it is 7·12. Sheet-zinc expands and contracts by about the same amount as lead does for rise and fall of temperature; consequently, the same precautions must be taken to allow it free play when used as a covering for roofs.

The effects produced by heat upon wood are very different from those produced upon metals, as might be expected from its being an organic substance. When newly-cut or unseasoned wood is exposed to a moderate amount of dry heat its dimensions are

found to contract, owing to the escape of some of the moisture which it contains in its natural state. At the same time, its power of resistance to strains is greatly increased after being kept for a considerable period in a dry and warm chamber. Thus, for example, we find that specimens of red deal have their crushing strength increased from 5,748lb. to 6,586lb. per square inch; of white deal, from 6,780lb. to 7,293lb.; of Quebec oak, from 4,230lb. to 5,982lb.; of English oak, from 6,484lb. to 10,058lb.; of red pine, from 5,395lb. to 7,518lb.; and of walnut, from 6,063lb. to 7,227lb. The process of boiling or steaming timber for the purpose of bending it does not appear to affect its strength in any material degree, provided it is only continued for a few hours; but if kept up for a long period the wood loses much of its resisting power. On the other hand, if timber is exposed for a long time to a high degree of dry heat, its strength is greatly diminished, and it becomes very brittle—a certain amount of moisture being essential to its strength.

When clay is burnt into bricks the effects produced by different degrees of heat are very conspicuous, the bricks which are nearest the fire being generally overburnt and clinkered so as to render them unfit for building purposes, whilst those most remote from the fire are often insufficiently burnt, and are called place-bricks, from their being too soft to be used for outside walls, as they crumble when exposed to weather, and

do not possess sufficient strength to stand any great crushing load.

When rays of heat fall upon clear glass one portion of them is reflected from its surface, another portion is absorbed by the material, and its temperature is thereby raised, while the greater part of the incident rays passes through the glass to the other side. The proportion of the transmitted rays depends somewhat on the thickness of the glass, since plate-glass $\frac{1}{4}$in. thick transmits 60 per cent. of the incident rays, while glass 1-16in. thick transmits 70 per cent. of them. About 10 per cent. of the incident rays are reflected from the surface of glass in the same manner, and according to the same law as those of light are reflected, and consequently about 30 per cent. are absorbed or dispersed by glass $\frac{1}{4}$in. thick, and 20 per cent. by glass 1-16 thick. Although the expansion of glass when heated is very small in quantity, yet it is sufficient sometimes to produce fracture in large sheets if too tightly fitted into frames formed of unyielding material. Thus a sheet of glass 10ft. long, will expand 1-10in. in length if raised through 100° of temperature, so that if fixed firmly in iron frames, which also expand when heated, it follows that fracture must necessarily ensue, especially where the glass is very thick, and will not readily bend. The low conducting power of glass also often causes the fracture of thick plates, for if they are heated to a considerable degree, and are then

suddenly cooled on one side, the unequal shrinkage will produce a crack in the glass. The brittleness of glass can be much reduced by carefully annealing it, which is done by cooling it very slowly from a high temperature; plunging in boiling water or oil, and allowing it to cool gradually, adds much to the toughness of glass.

The absorbent power which materials possess for rays of heat differs widely in various substances, and depends a good deal on the nature of the surface exposed. If a surface is coated with lampblack, or with white-lead, the whole of the heat rays are absorbed, which causes the temperature of the body to rise rapidly, and the heat is then given off again by radiation, so that it is not advisable to use these materials on portions of a building much exposed to the sun's rays. Metallic surfaces, such as those of iron, zinc, or lead, absorb only 13 per cent. of the incident rays of heat, and consequently do not become very rapidly heated by exposure to the sun or any hot body. Bright zinc reflects 80 per cent. of the incident rays, iron 75 per cent., and lead 56 per cent.; the difference between these quantities of heat reflected and the amount absorbed being dispersed or reflected in an irregular manner. Dark-coloured slates absorb much of the heat which fall upon them, which renders a room immediately under a slated roof very hot in summer; it is found that a coating of white-

wash laid on the outside of the slates reduces very much their absorbent power, although a coating of white-lead paint would have, as we have noticed above, the opposite effect of increasing the absorption of heat.

In the construction of furnace chimneys it is of great importance to use such materials as are bad conductors of heat, so that the draught of the flue shall not be reduced by the lowering of the temperature through the escape of heat to the outside. A chimney built of stone will lose only one-twentieth of the heat that an iron flue would lose, since stone is a bad conductor as compared with metal, and one built of brick, which has still less conductivity than stone, will lose less heat in proportion. A great loss of heat, however, is occasioned when newly-built chimneys of stone or brick are used before being thoroughly dried, from the quantity of moisture they contain, the evaporation of which absorbs a large quantity of heat, which becomes latent in converting it into vapour. If a material is used which is pervious to rain, there will always be a difficulty in keeping up the draught of the flue, owing to the same cause, which renders a double casing desirable in such structures.

APPENDIX.

Property owners who may desire to frame a list of precautionary instructions for the attention of their employés, may find it advantageous to select those items applicable to their particular case from the following extracts from drafts prepared by the author for numerous establishments.

Fire Protection.

The following instructions are framed with a view to protect these premises against fire, and for the benefit of all concerned, it is hoped they will be carefully and frequently read and considered by each employé:—

Precautions against Fire.

Gas must be properly guarded, and especial care taken with jointed brackets. Each burner must be carefully turned off when no longer required, and turned off at the meter in case of a serious fire. If an escape of gas occurs, open windows and doors, and, to prevent an explosion, seek the defect without using a light.

Matches are not to be brought into the building by employés, and none but authorised persons are to make use of either matches, tapers, candles, or lamps, which, when ignited, must be cautiously used, and every precaution taken to prevent their flames getting into contact with inflammable material. Their light must in all cases be fully extinguished when no longer required, and before laying aside.

Matches must not be thrown or left about, and paper must on no account be lighted.

Smoking in any part of the premises is strictly forbidden, and workmen must fully extinguish their pipes before putting them into their pockets, or entering the building.

Reading and smoking in bed are both dangerous, and are forbidden.

Each Employé should be acquainted with the various means of escape by the staircases, etc., and occasionally think how he or she would act in case of an alarm of fire, so as to be better prepared, if one should occur.

All doors and openings to lifts should be closed between business hours, and in the event of a fire.

Fire Escapes are placed in various rooms of the upper floors. They must be kept unhampered, ready for use, and each person should be acquainted with the position of the rooms in which they are located.

Hydrants and Hose, Hand Pumps, Buckets, etc., are placed in various parts of the premises, and it is desired that each and every person shall be acquainted with their position, as well as their proper use and working.

A private fire brigade is formed among the male employés, who receive periodical instruction, and it is their duty to make themselves fully acquainted with the whole of the fire appliances, and learn how to confine and extinguish a fire which might occur in any part of the building.

The (or Mr.)..... .... is responsible that all fire apparatus is kept in good condition, clean, ready for use, and in its proper place, conspicuous and handy.

In the event of a Fire,

Be calm, preserve presence of mind, and do not cause confusion. Inform the chief of the department, who will ascertain the nature and position of the fire, and do not generally leave your positions until you know there is cause to do so.

If you have reason to believe the fire is dangerous, convey the fact speedily and quietly to all within the premises.

If in bed, wrap yourself with a blanket, or whatever is quickly

available, and close the door on leaving your room. Remember the fire escapes and exits to roof, but descend by the stairs if practicable.

Free breathing may be had in dense smoke by covering the nose and mouth with a damp towel, flannel, or handkerchief (not too thickly folded), and crawling on hands and knees, keeping the face near the floor.

Close all doors and windows, to exclude draught.

Strong employês take charge of the doors, and refuse admission to unauthorized strangers, prevent unnecessary removal of goods, and watch any it may be necessary to remove.

Remember a fire may be quickly put out if the appliances in the building are speedily and energetically used, and in this everyone should assist to the utmost of their ability, obeying the orders of their superiors, and taking care not to act recklessly and do unnecessary damage.

The *Buckets of Water* will put out a fire, if the water is thrown on to the burning material immediately after the outbreak.

The *Hand Pumps* (or chemical extinctors) should be quickly put into use.

The *Hose* should be attached to the nearest hydrant, laid out to the fire, and the nozzle screwed on to the extreme end with all speed, and if the fire is not then put out turn on the hydrant. The nozzle should be taken as close as possible to the fire, and the person directing it should not merely play into the flame, but seek to strike with force the material which is burning, moving the nozzle about with judgment, so as to strike at the whole burning surface (and not one point alone); and occasionally saturate the surrounding material to prevent the flames extending. If the fire is likely to extend, one or two more hydrants may be put into use after the first is at work, so as to confine the fire to the floor and room in which it originated.

If anything impedes the extinction of the fire, remove, cut, or break it away.

If a person's dress takes fire, roll them on the floor, or wrap them tightly in a coat, rug or carpet, and then send for a medical man.

Immediately upon any Alarm of Fire,

One person must hasten to the Fire Station ....

....

Another to the Turncock ....

....

Another inform the nearest constable.

If at night, go at once to the fire escape at ....

....

To alarm a Fire Station by means of the Electric Fire Alarm

(Recently fixed in many of the thoroughfares of London)

Break the glass, pull out the knob (or push it in, according to the kind of instrument, there being two systems at present in use), and when the white disc re-appears in the dial it will show that the message has been received at the fire station. Remain at the alarm post until the firemen arrive, and then direct them to the scene of the fire.

IN CASE OF FIRE, SEND TO*—

FIRE ENGINE STATION ....

SALVAGE CORPS' STATION..

FIRE ESCAPE, *by day*..

FIRE ESCAPE, *at night* ....

WATER WORKS' OFFICE ....

OR TURNCOCK ....

CHIMNEY SWEEP (for a Chimney on Fire) ....

MEDICAL MAN..

HOSPITAL, in cases of acccident to a person..............................

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* The purchaser of this book should complete the above by filling in the nearest address in each instance, so that they may be readily referred to upon an emergency.

ADDENDA.

SINCE this work passed through the press, the author's attention has been drawn to a recent application of asbestos in the manufacture of paint for the protection of inflammable materials against fire.

The mineral substance known as asbestos has for many years past appeared in a variety of forms, and received extensive and satisfactory adoption for packing the joints of steam, hot water and hot air cylinders, pipes, cocks, &c., to prevent leakage, for coating steam boilers and pipes, engine cylinders, &c., to thwart the radiation of heat and consequent loss of power, and other purposes for which its fire-resisting and indestructible qualities have been long and almost universally known. But it is only recently that the material has been worked into a form of paint by the United Asbestos Company, who, having experimented and proved the fire-resisting nature of certain ingredients when combined with pure asbestos, have placed the compound before the community as one which can be both economically and effectively substituted for ordinary paint of any colour in coating beams, joists, rafters, stairs, doors, window frames, and woodwork of all kinds, as well as many other inflammable materials, among which canvas may be enumerated.

It is claimed by the manufacturers of this "Asbestos Paint" that combustible materials, when coated therewith, cannot be made to take fire, and will not therefore act as fuel to any flames which may attack it, and this appeared to be successfully proved on the occasion of some exhaustive trials which were lately made in order to publicly demonstrate the fact.

The new paint appears to be mixed in a manner which renders it capable of being applied to the material it is desired to make non-combustible by any ordinary person who understands the application of common paint, and it may be added that as ropes, clothes, sheets, and other articles are capable of resisting fire when woven with asbestos, there can be no doubt but that the general adoption of such materials will greatly tend to confine, or altogether prevent, many conflagrations, which might otherwise prove disastrous to both life and property.

THE UNITED ASBESTOS COMPANY, Limited.

161, QUEEN VICTORIA STREET, LONDON, E.C.

Manufacturers of Pure Asbestos Goods in a great variety of forms.

Perfectly Indestructible by exposure to Fire or Weather.

Asbestos Millboard, for steam and all kinds of joints. Sold in sheets, or joints cut to order.

Asbestos Woven Packing, for glands.

Asbestos Paper, for very fine joints.

Asbestos Cloth, for chemical filtration and other purposes.

Asbestos Putty, cement, fuel for gas fires, and composition for covering boilers and steam pipes.

SPECIAL.

ASBESTOS FIREPROOF PAINT, for coating inflammable material of every kind in order to render it fireproof. The woodwork of the theatre at the Crystal Palace has been painted with this paint. See *Times* and *Standard,* December 24, 1881, *Daily Chronicle* and *Daily News,* December 23, 1881.

ASBESTOS ACID PROOF PAINT, for outside painting. Its durability has been proved by the most severe tests, chemically and otherwise. Its insolubility and power to resist the action of the gases, acids and weather, and the fumes of sulphuretted hydrogen and ammonia arising from steam and smoke, renders it most valuable for bridges, especially railway bridges and girder work, stations, locomotives, carriages and waggons, and for general structural purposes, docks, gas works, &c., &c.

It is a well known fact that the atmosphere of every large manufacturing town is heavily charged with sulphurous acid, sulphuretted hydrogen, ammonia, and other gases which soon act on all ordinary paints, quickly destroying their colour and adhesive qualities; but Asbestos Paint, being made from a natural, insoluble, fire and acid resisting product, cannot be acted upon in this way.

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ADVERTISEMENTS.

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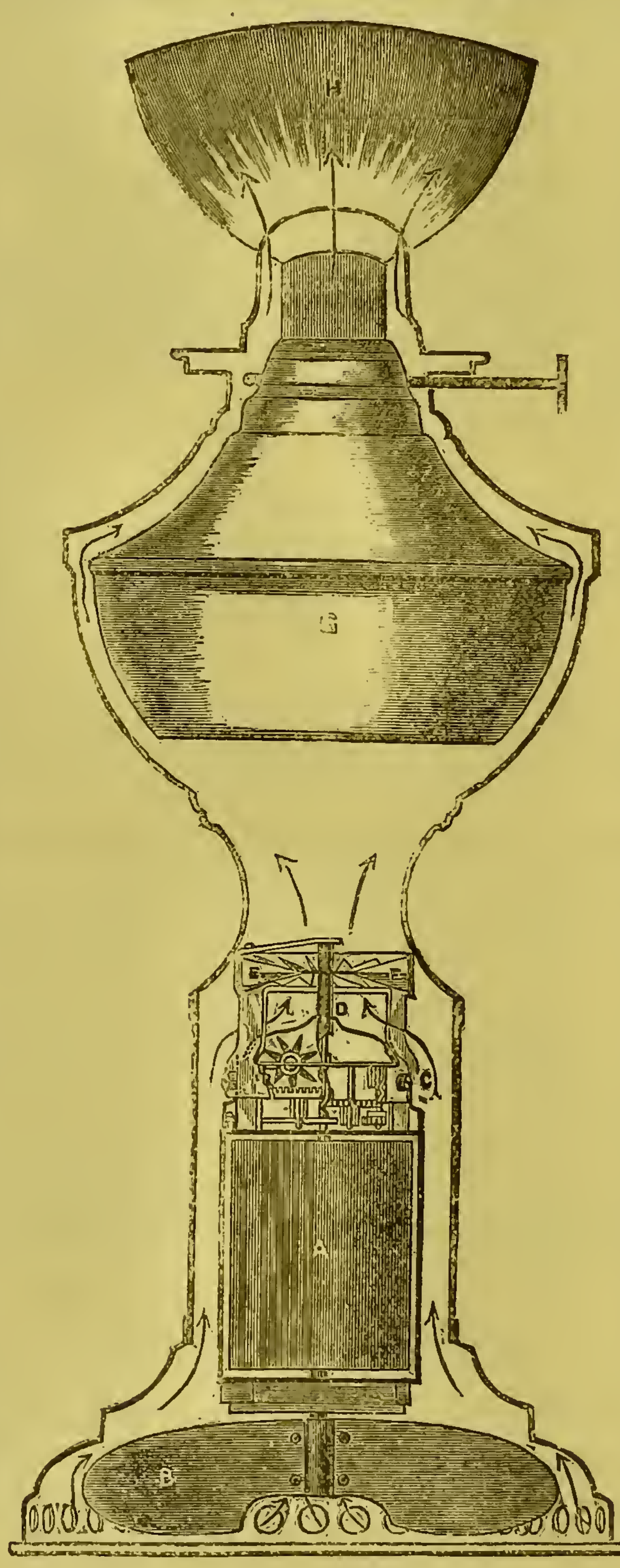
Hoyne's Patent "EMPRESS" Lamp.

For BURNING KEROSENE, PETROLEUM, PARAFFIN or ROCK OIL without Chimney or the necessity of a Globe producing the action of a Chimney.

The advantages gained by the use of this Lamp are Brilliancy of Light, with comparative absence of heat, enabling a room of any size to be brilliantly illuminated without appreciably raising its temperature.



This part section shows the construction of the Lamp; A. the mechanical arrangement; E.E. the horizontal fan by which the air supply is obtained, and the current around the cistern G. is affected, and afterwards caused to impinge upon the flame H. in their simultaneous passage through the cone. B. is the key for winding the mechanical air supply arrangement.

JOHNSTON & CO., 104, NEWGATE STREET, LONDON, E.C.